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The Application of a Dryer Solar Energy Hybrid to Decrease Workload and Increase Dodol Production in Bali

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Abstract

Dodol is one of the typical traditional snacks in Bali. Dodol is a food favored by both domestic and foreign tourists. The process of making dodol are through several stages, namely making the dough, stirring the dough until cooked, wrapping dodol, and the last stage is drying dodol. The process of drying is done by natural methods of drying and using traditional work tools. The process of drying under the sun causes an additional workload for the worker, tiredness, and less optimal production of dodol. Therefore, research was done to provide a solution to this problem that is the application of a dryer solar energy hybrid. This research was conducted experimentally using treatment by subject design. The sample size is 20 people. The samples were given two treatments, namely the work of making dodol the old way (period 1) and working to make dodol in a new way using the application of techno-ergonomic hybrid solar energy (period 2). The workload is calculated based on worker's working pulse and %CVL (Cardio Vascular Load), while the production amount is calculated from the amount of dodol produced in one production cycle. To know the difference between period 1 and period 2, data were analyzed using the t-pair test at 5% significance level. The results showed that there was a decrease of workload by 15.3%, a decrease of %CVL by 41.4%, increase of production amount 167%, and improvement of dodol product quality. It was concluded that the application of hybrid solar drying can decrease the workload of dodol workers and increase the production and the quality of dodol in Bali.

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1. Introduction

Dodol is one of the typical traditional snacks in Bali. This special food is much favored by both domestic and foreign tourists, so it is sold in various places and made souvenirs typical of Bali for the tourists. The process of making dodol through several stages, namely making the dough, stirring the dough until cooked, wrap, and until the last stage of drying dodol. The process of drying was done by workers with natural methods of drying and using traditional work tools. Dodol was spread over woven bamboo and then drying.

According to Maheswari & Wulandari (2004), if the water content in dodol ranged between 20.05% -26.61%, dodol can only last for ± 2 weeks. By applying controlled heating to temperatures of 80˚-85˚C, good sanitation as well as improved packaging design, able to maintain the product for more than 8 weeks. Lack of warming, as well as unfavorable packaging, causes dodol products found on the market to be damaged (rancid odor) due to mold contamination, one of which is the species Syncephalastrum racemosum. If it is old, this type of mold when reproducing will form a white and gray colony. This fungus is highly avoided because it can damage the sensory quality of dodol products, based on this matter required an effort to inhibit fungal contamination so that consumers are not harmed (Saptarini, 2007). In order that the product is said to be of good quality, the product must conform to the established standard (SNI, 1992).

Based on preliminary research on six samples, the average drying temperature is 33,43 ± 1,34oC; average drying time 13.57 ± 0.63 hours. The average working pulse rate of 110.5 ± 6.09 beats/min and included in medium workload category (Kroemer & Grandjean, 2000). The mean score of musculoskeletal disorders was 51.5 ± 5.89 and is classified as moderate risk level or corrective action is required (Tarwaka, 2011). The mean fatigue score of 53.17 ± 4.07 and classified as moderate fatigue classification or corrective action required (Tarwaka, 2011). Average work productivity 0,004348 ± 0.00039 kg/hour.dpm. The complaints felt by the dodol workers were a pain in the neck, shoulders, back, waist, head, and hands. This, of course, leads to decreased performance of workers.

Ergonomic problems in the process of drying the dodol in Bali can be solved by the application of ergonomics through changes in work tools, thus improving work posture, working time, reducing musculoskeletal disorders, fatigue and exposure to solar heat. The use of ergonomic work tools will create natural work posture and working methods of workers more effective, convenient, safe, healthy, and efficient. Ergonomic work equipment can improve comfort and reduce the risk of work accident (Kroemer & Grandjean, 2000).

Thermal solar dryers are used when the weather is sunny, while in cloudy or rainy weather biomass dryer is used. The utilization of biomass through combustion in the furnace and the resulting hot air is flowed using a heat exchanger. The biomass used is coconut husk, as it is easily obtained and is found in many neighborhoods where workers live. Biomass is organic materials derived from microorganisms, both animals, and plants such as leaves, grass, twigs, weeds, agricultural wastes, farm waste, and peat.

Based on the above description, it is necessary to carry out research on the techno-ergonomic hybrid solar dryer as a way of improving the work tool in dodol drying process with ergonomic intervention through SHIP (systemic, holistic, interdisciplinary, participatory) approach and application of appropriate technology. This needs to be done to determine the effect of ergonomic hybrid solar dryers on the temperature of drying, drying time, drying rate, workload, musculoskeletal complaints, fatigue, work productivity, and dodol quality.

2. Materials and Methods

This study was conducted experimentally with Treatment by Subject Design (Colton, 2008). The target population is dodol maker in Bali, while the affordable population is dodol maker in Buleleng Regency which amounts to 275 people. The number of samples obtained from the calculation is 20 people. The samples were given two treatments, namely the work of making dodol the old way (period 1) and working to make dodol in a new way using the application of techno-ergonomic hybrid solar energy (period 2). The techno-ergonomic hybrid solar dryer is a tool for the ergonomic intervention-drying process with solar and biomass energy sources comprising drying chamber, solar collector, heat exchanger, furnace and ergonomic hybrid solar Dryer. This tool is shown in Figure 1 below.

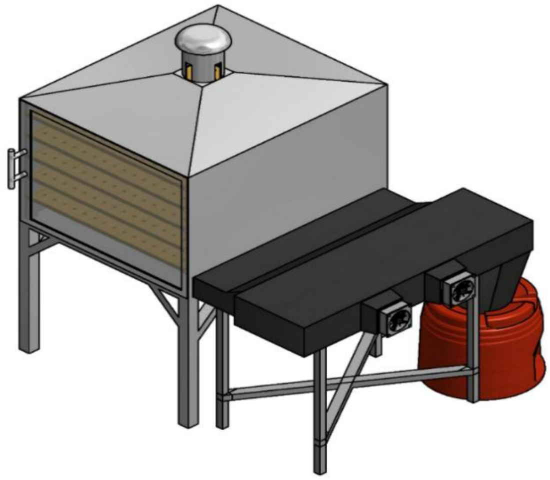

Figure 1. The design of the techno-ergonomic of dryer solar energy hybrid

Workload was calculated based on the worker's working pulse, while the quantity of production was calculated from the amount of dodol produced in one production cycle. To know the difference between period 1 and period 2, data were analyzed using the t-pair test at 5% significance level.

3. Results and Discussions

3.1 Subject Characteristics

The subjects of this study were female workers and lived in Bali. Characteristics of the subject consist of age, height, weight, work experience, and body mass index.

Table 1
Subject Characteristics Analysis

Variables	Mean (n = 20)	SD	Range
Age (year)	29.67	9.12	21.00 – 49.00
Body Height (cm)	155.17	5.12	146.00 – 162.50
Body Weight (kg)	54.27	6.14	47.21 – 67.54
Working Experience (year)	22.08	3.19	18.92 – 24.32
BMI (kg/m2)	8.76	7.34	1.00 – 30.00

SD = standard deviation

The average age of the subject is 29.67 years and the age range is 21 - 49 years. This age range still belongs to the working age group and is a productive workforce. The average age of the study subjects is still relatively optimum, but at the age of 30 will decrease, since the optimum muscle strength for recommended work is between 20 to 30 years (Tirtayasa *et al.,* 2003). The average working experience of the subject is 8.76 years. This indicates that the subject has been skilled and able to adapt to their work. Work experience in formal/informal sector work is generally considered to improve a person's work ability (Robbins & Timothy, 2009).

The mean body mass index (BMI) sample in this study was 22.08 kg/m^2. This indicates that the worker's body mass index is in normal nutritional status. Normal BMI of Indonesians ranges from 18.5 to 25 kg/m^2 (Almatsier, 2001). BMI is an indicator of body fat, if BMI below 18.5 kg/m^2 is very underweight, while above 25.0 kg/m^2 is obesity (overweight) due to excessive fat accumulation (Ranasinge *et al.,* 2013).

3.2 Work environment Conditions

Environmental conditions at the study sites were measured at the time the worker did the dodol drying process. Environmental conditions in this study consisted of dry temperature, wet temperature, relative humidity, light intensity, sound intensity, and wind velocity.

Test the normality of data on working environment condition using Shapiro-Wilk test (n <50). The result of data analysis shows that the working environment data was normally distributed (p> 0,05) both in period 1 and period 2. Because of normal distributed data, the difference of working environment data analysis in period 1 and period 2 using t-paired test. The results of the analysis are shown in Table 2 below.

Table 2
Working Environment Condition Analysis

No.	Uraian	Periode 1		Periode 2		t	p
		Mean	SD	Mean	SD		
1.	Wet Air Temp (°C)	28.73	1.22	29.12	1.22	4.571	0.326
2.	Dry Air Temp (°C)	34.03	0.92	34.71	1.18	2.754	0.864
3.	Relative Humidity (%)	68.77	2.73	69.17	3.08	3.915	0.287
4.	Light Intensity (Lux)	1976.34	34.76	1964.21	36.72	9.,28	0.312
5.	Sound Intensity (dB)	68.97	1.08	69.55	1.29	2.876	0.451
6.	Wind Speed (m/det)	1.21	0.03	1.17	0.04	0.915	0.331

SD: Standard Deviation

Table 2 shows that the working environment microclimate conditions both in period 1 and period 2 were still within the boundaries of adaptation to perform a work activity. Variables of wet temperature, dry temperature, relative humidity, light intensity, sound intensity and wind speed have no significant difference between period 1 and period 2 (p> 0.05). The meaning is that the working environment between period 1 and period 2 can be considered the same and does not affect the research intervention. The microclimate condition is still within normal limits and feels comfortable in working. The threshold value of air temperature for workers is 33 oC and the relative humidity of Indonesian workers who are still relatively comfortable is between 60% - 80% (Manuaba, A., 2005). It is suggested as well that headgear is worn by the workers to prevent excess heat to the face and head and other body armor so that workers can work comfortably (Cornelis, et al., 2015).

3.3 Dryer Performance

To measure the performance of dryers in this research, the performance difference test was conducted using the old method (period 1) and the new method (period 2) on drying temperature, drying time, and dodol drying rate. The results of the analysis are shown as in Table 3 below.

Table 3
Dryer Performance Analysis

No.	Variable	Periode 1		Periode 2		t	p
		Mean	SD	Mean	SD		
1	Drying Temperature (°C)	34.82	5.18	41.32	6.22	12.572	0.001
2	Drying process time (hour)	12.50	12.71	8.25	8.25	6.197	0.001
3	Drying Rate (kg/hour)	1.39	0.03	2.23	0.02	1.296	0.001

SD: Standard Deviation

Table 3 shows that there was a difference in performance in the old way (period 1) and the new way (period 2). Period 2 provides a higher drying temperature, faster drying time, and faster drying rate. So it can be said that the hybrid solar dryers have a good performance.

3.4 Workload

Workload workers were predicted by measuring the resting pulse, work pulse, and % CVL. The results of the analysis are shown in Table 4 below.

Table 4
Work Load Analysis

No.	Variable	Periode 1		Periode 2		t	p
		Average	SB	Average	SB		
1	Resting Pulse (beat/minutes)	67.00	2.04	68.00	1.70	1.782	0.319
2	Working Pulse (beat/minutes)	114.84	1.76	97.28	0.77	27.819	0.001
3	% CVL	36.82	4.50	21.58	2.65	11.227	0.001

SD: Standard Deviation

Table 4 shows that the resting pulse between period 1 and period 2 does not differ significantly (p> 0.05), it means that the initial conditions can be considered equal so that the initial conditions do not affect the effect of ergonomic interventions given to the worker. Then, There was a significant difference (p <0.00) in the variable of working pulse rate and %CVL between period 1 and period 2. On the basis of the mean, period 2 gives the mean value smaller than the period 2. This indicates, there was a decrease in the workload of workers.

Working pulse decreased from 114.84 beats per minute (Period 1) to 97.28 beats per minute (period 2) or decreased by 15.3%. The classification of workloads in period 1 was in the category of "medium" workload because in the range of 100 - 125 beats/min, while in period 2 is a light workload that was in the range of 80-100 beats per minute (Kroemer & Grandjean, 2000). The decrease in workload is due to ergonomic intervention in the form of the improved work environment and work posture. Ergonomic interventions with changes in the work system will lead to decreased workload and increased work productivity (Anna & Tadeusz, 2013; Santosa & Sutarna, 2016). The mean cardiovascular load (CVL) also decreased significantly (p <0.05) from 36.82 to 21.58 or decreased by 41.4%. The percentage value of this cardiac workload (CVL) was in the medium workload category that was between 30% - 60% (Manuaba & Kamiel, 1996).

3.5 Production and Quality of Dodol

There was a significant increase in dodol production from period 1 to period 2. The results of this improvement analysis were shown in Table 5 below.

Table 5
Dodol Production Analysis

No.	Variable	Periode 1		Periode 2		t	p
		Average	SB	Average	SB		
1	Produksi Dodol (buah/siklus)	570.23	14.78	1,522.90	17.32	35.876	0.001

The average of production of lunkhead in one production cycle in period 1 was 570.23 pieces, while in period 2 was 95.332,47 fruits/cycle or increased by 167%. To know the comparison of product quality in period 1 with period 2, tested the quality of dodol. The quality of dodol in each period has been tested in laboratory testing at UPT-Analytical Laboratory Udayana University, Indonesia. Results of laboratory testing compared with the requirements of SNI (Indonesian National Standard), 1992, on dodol quality requirements. The results of laboratory tests of dodol are presented in Table 6 below.

Table 6
Comparison of Dodol Quality with Requirements (SNI, 1992)

No.	Parameter	SNI, 1992	Periode 1 (%)	Periode 2 (%)
1.	Water content	Max. 20%	26.19	19.12
2.	Ash content	Max. 0,3%	0.4	0.24
3.	Protein	33.4%	22.09	34.01
4.	Fat	3%	4.83	2.75
5.	Carbohydrate	0	1.53	1.11

The dodol laboratory test resulting from the drying process using ergonomic hybrid solar dryers is in conformity with the requirements of SNI (1992), as shown in Table 6. Generally, the ergonomic interventions applied to the drying process have an effect on the improvement of dodol quality. The quality of this product can also be enhanced by using relevant appropriate technology options (Taher, 2010; Yusuf *et al.,* 2016). Ergonomic interventions are also capable of improving production, and worker productivity (Emile *et al.,* 2013; Lia *et al.,* 2015).

4. Conclusion

Based on the discussion that has been done then can be conveyed conclusion as follows:

a) The application of a dryer solar energy hybrid can decrease workload of dodol worker in Bali
b) The application of a dryer solar energy hybrid can increase dodol production in Bali
c) The application of a dryer solar energy hybrid can improve quality of dodol in Bali

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Statement of authorship
The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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